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Dry Gas Seal Failure due to Axial Sub-synchronous Vibration on a Hydrogen Recycle Gas Compressor.

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Bio: Robert C. Eisenmann, Jr.

Currently the BP Refining Machinery Advisor and Downstream Segment Engineering Technical Authority (SETA) with Refining Technology and Engineering based in Houston, Texas. He provides technical advice to the BP global refining portfolio to support business delivery, company strategy, industry direction, and technical assurance to support business decisions. He also promotes technology solutions and development and implementation of best practices across the BP refineries. He is currently the API 618 Chairman, API 692 Chairman, serves as a SME for BP's Engineering Technical Practices and has been a member of the Texas A&M Turbomachinery Advisory Committee since 2012. Bob has over 25 years of experience in the industry. Bob graduated from Texas A&M University at Galveston in 1992 with a B.S. in Marine Engineering.

Bio: Luis Santos-Gutierrez

Currently the BP Rotating Equipment Engineering Superintendent at the BP Whiting Refinery in Whiting, IN. He leads the rotating equipment engineering team and acting subject matter expert for process rotating equipment at the site. Luis is responsible for the Life Cycle Management of the refinery's rotating equipment fleet and delivery of the rotating equipment strategy .

Luis has over 18 years of experience in the industry in various machinery engineering and project commissioning roles. He is a graduate from the University of Puerto Rico at Mayagüez with a B.S. in Mechanical Engineering.

Abstract

Approximately 6 months after commissioning a new hydrotreater hydrogen recycle gas compressor the site experienced a dry gas seal failure. The investigation revealed wear of the primary seal dynamic sealing element due to movement thought to be caused by design and installation issues. The onset of a second failure indicated the root cause had not been identified. Further investigation discovered the compressor was experiencing high axial vibration during operation ultimately causing the seal failures.

This case study will present the data from each failure, monitoring methods used, analysis conducted, options evaluated and the corrective action taken to resolve the problem.

Hydrogen Recycle Compressor

- Commissioned in November 2013
- Motor/Gearbox/Compressor Train
- 12,500 hp (9.325 MW) 4 pole synchronous motor (1800 rpm)
- Speed increaser gearbox with 12,733 rpm output speed

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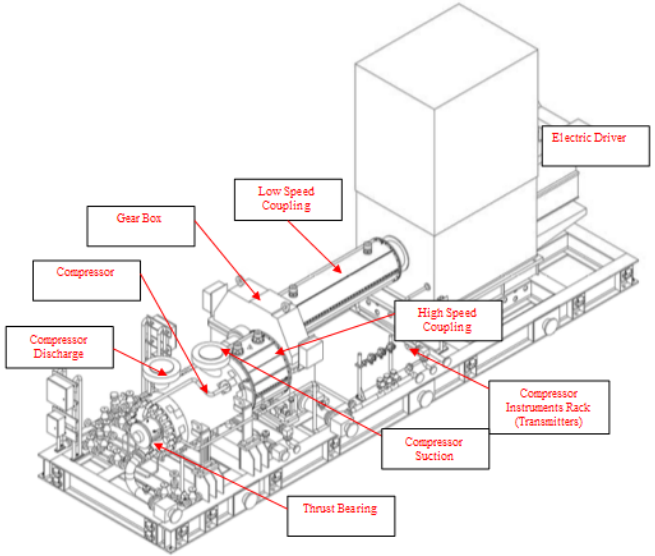
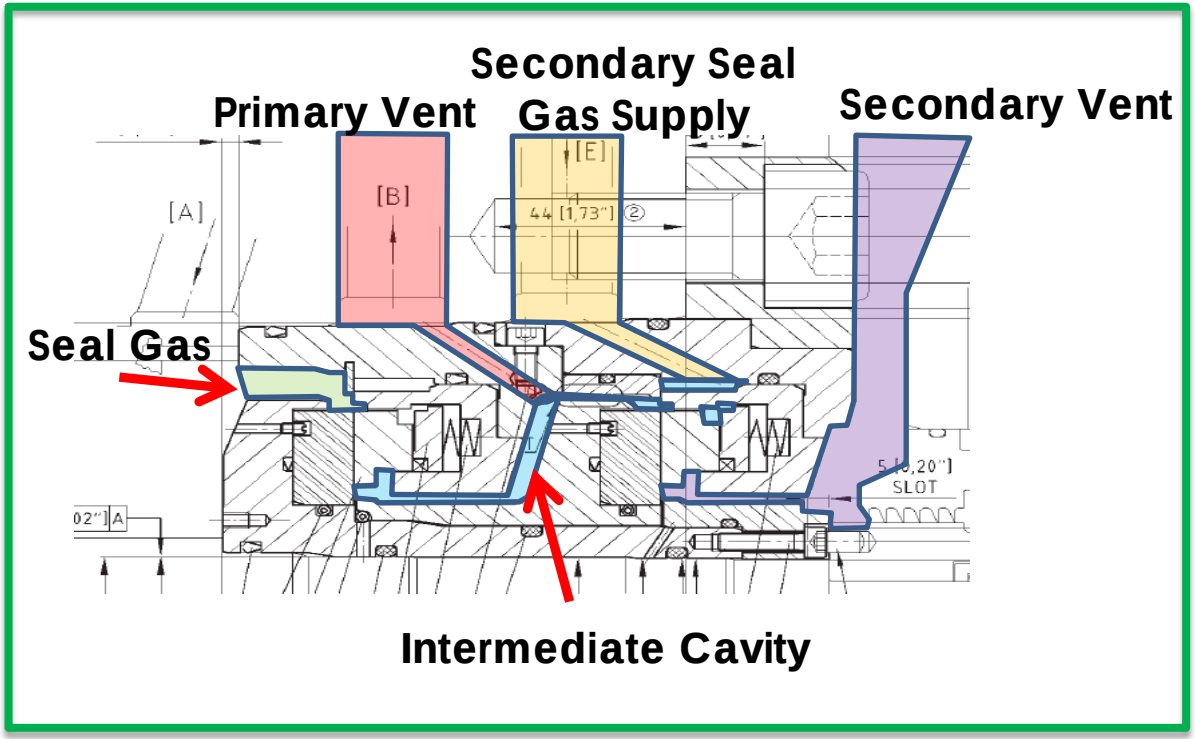
- 7 stage straight through centrifugal barrel compressor
  - Gas MW range from 2 MW to 5.3 MW
  - ~ 1840 psi (127 bar) suction pressure
  - ~ 2200 psi (152 bar) discharge pressure



Tandem Dry Gas Seal with Intermediate Labyrinth

- Flow control
- Gas Conditioning Unit (GCU)
- Fully instrumented system
- Secondary seal gas
- Primary vent backpressure controlled



The First Outboard Dry Gas Seal Failure

- Initial failure was detected 4 months after initial commissioning.
- Vent flow and control valve position changed over time indicating a degrading seal.
- Outage occurred in July of 2014 (~6 months of operation).
- Seals were replaced, failure investigated.

Increasing Vent Flow

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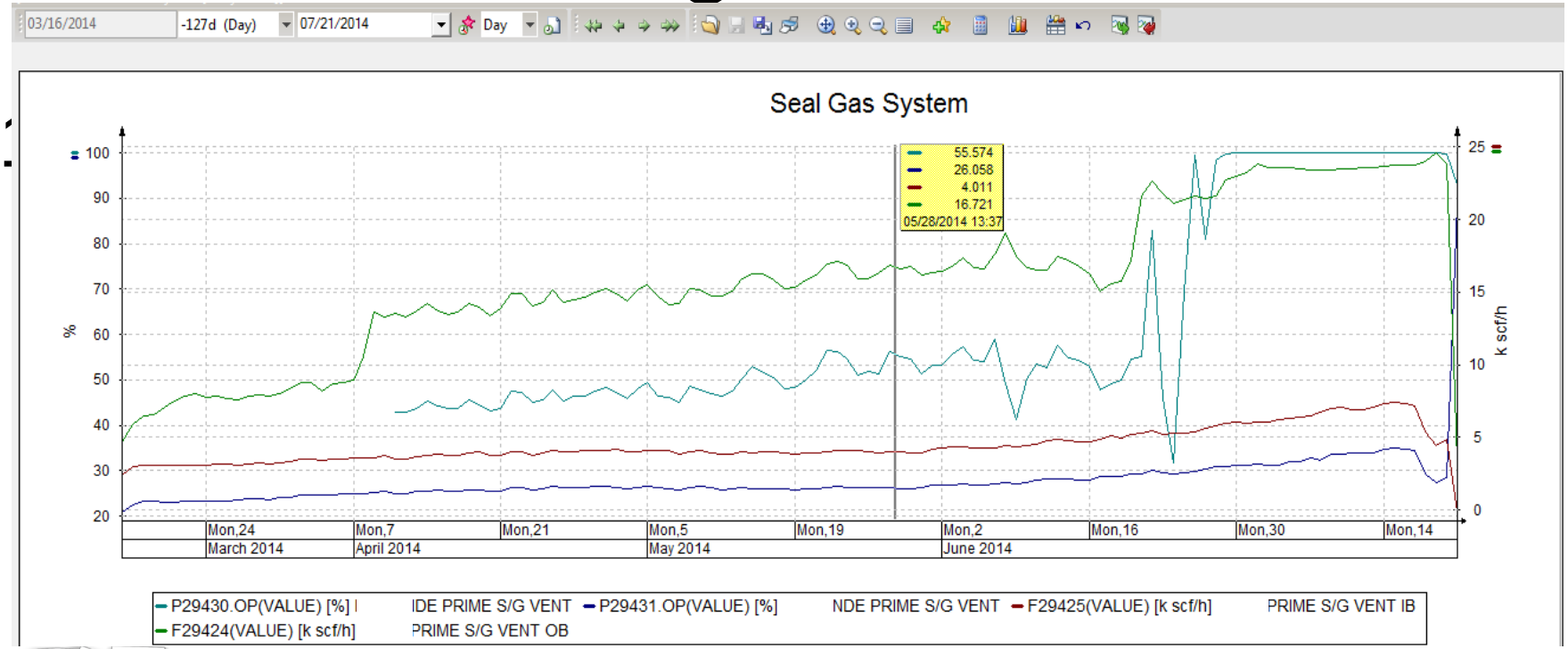
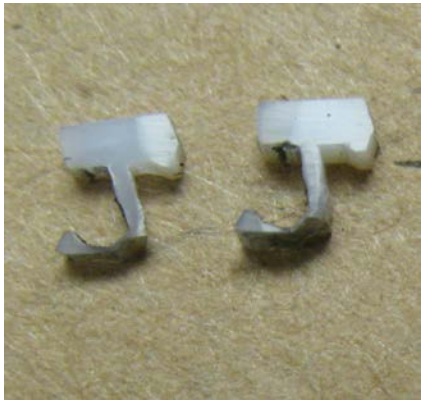
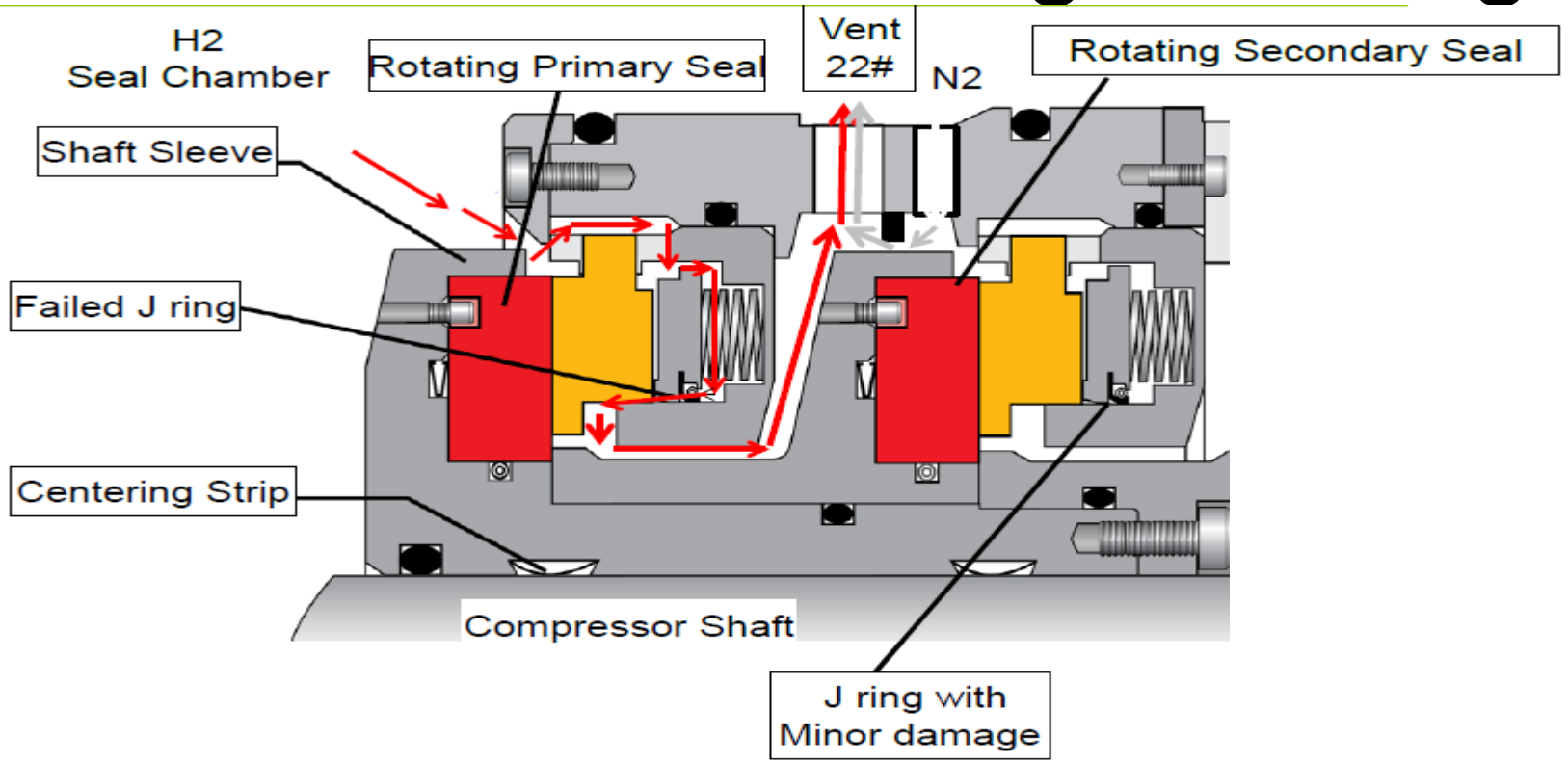


Failed “J” Ring and spring holder



Leak Path after J ring damage



Conclusion of 1st failure investigation...

- PTFE J-ring failed due to fretting and accelerated by:
  - Contamination/debris
    - Amplifier did not function during a previous unit shutdown
  - Swash (axial movement)
    - Indication of incorrect contact on nut assembly

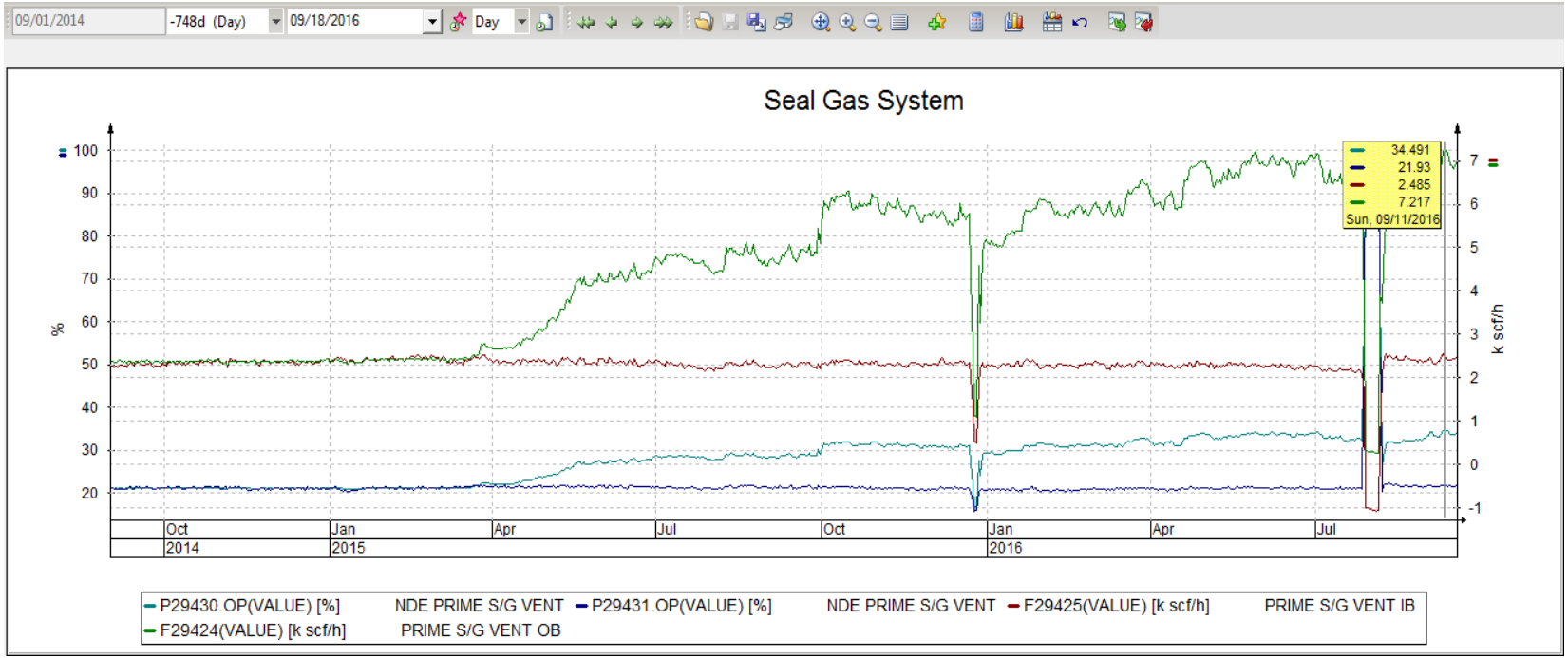
Actions taken from 1st failure

- Perform lapping and contact checks on the seal sleeve to locking nut to ensure perpendicularity and avoid potential for “swash”
  - Bluing showed 85-90% contact
- Perform run-out check on thrust collar to ensure that no axial run-out
  - Run-out found to be <0.0005”
- Seal gas booster was replaced
  - PM established to test functionality of seal gas booster

The Second Outboard Dry Gas Seal Failure

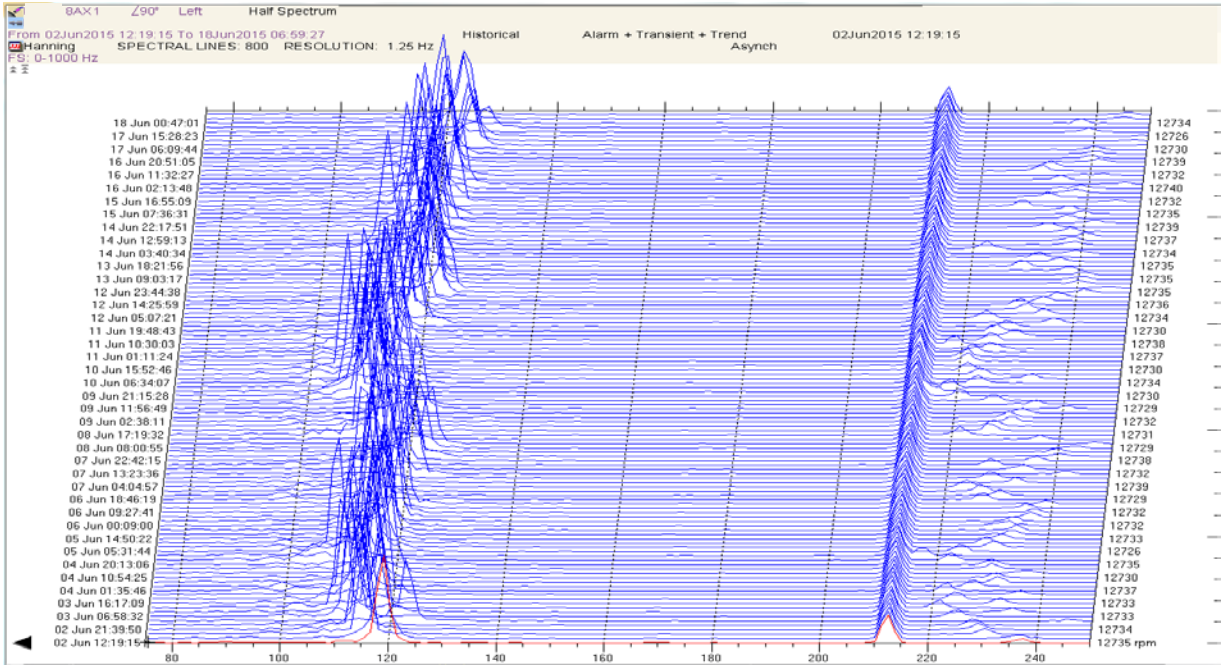
- Machine ran for 7 months with no issue.
- At 7 months noticed that vent flows and control valve position of outboard seals started changing indicating a degrading seal.
- RCA was re-initiated.
- Outage occurred in Fall of 2016 (~27 months of operation) to implement solution and address degrading seal.
- Same failure mode as first failure

Primary seal vent trends for 2nd run



2nd Failure Investigation

- June 2015 axial probes were configured to collect vibration
- Discovered sub-synchronous axial vibration around half running speed (110Hz-125Hz) with peaks up to 2.5 mils (0.0635 mm/sec)
- This finding shows that axial shuttling is happening under normal operation causing accelerated wear on PTFE J ring.

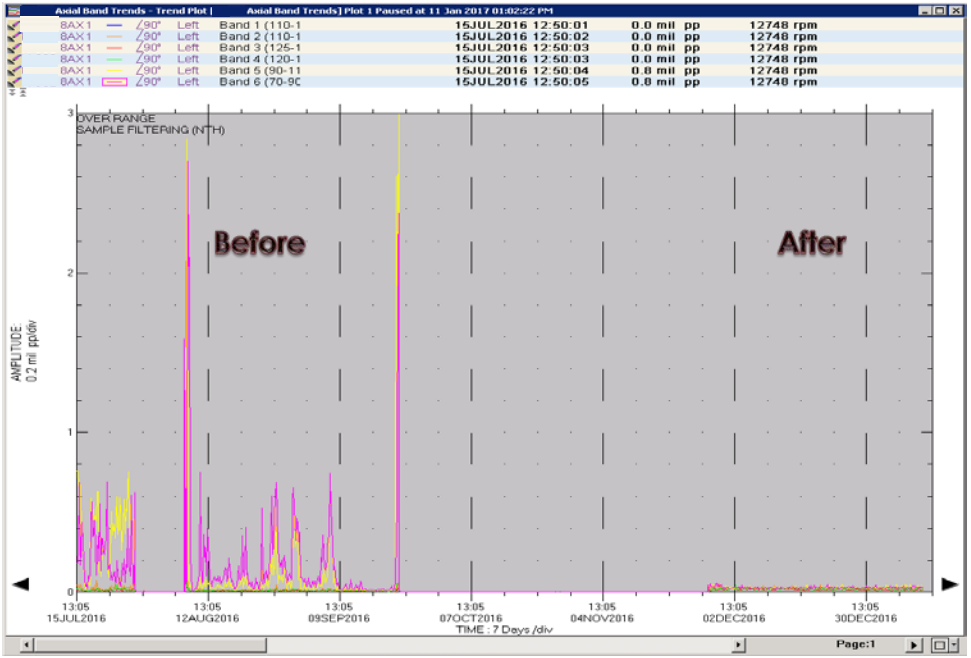


Solution Option

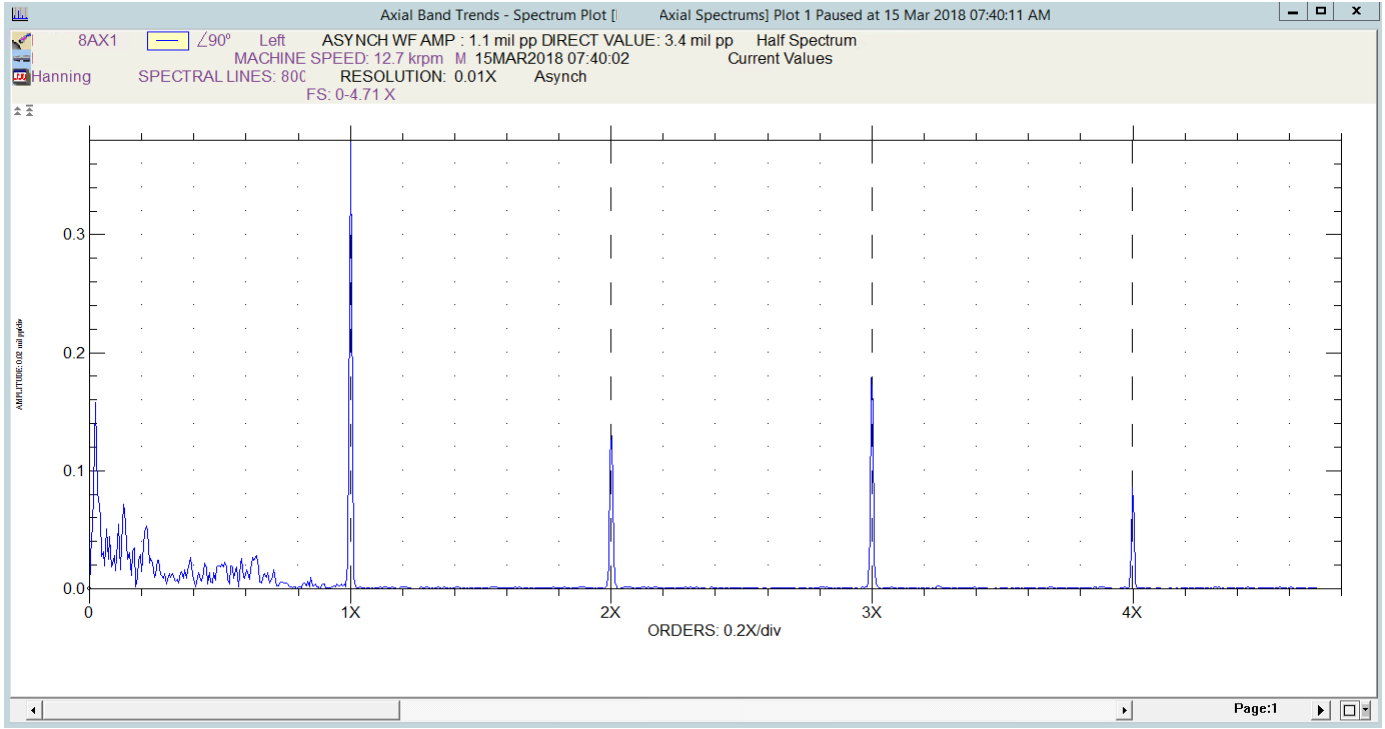
- Texas A&M paper by Scan DiCamillo; Kingsbury discussed axial vibration due to lightly loaded thrust bearings
- Test was conducted in order to manipulate
  - Increased and decreased oil pressure
  - Increased and decreased oil temperature,
  - Temporarily shut off coupling cooling oil spray
- Testing had minor influence on axial vibration frequency and amplitude
  - Largest response was when coupling cooling oil spray was shut off

Defect Elimination: H2 Recycle Compressor @GOHT

- Installed new pre-loaded thrust bearing in 2016 (Bearing with o-ring dampner)
- Axial vibration was reduced over 75% during normal operation.
- After 1 year of operation axial vibration has not increased from startup condition.



Current Spectrum – Minor Low Frequency Noise



Lessons Learned / Follow up actions

- Ensure H2 recycle compressors thrust bearing load is adequate to full range of conditions

- Axial vibration should be monitored at OEM FAT to determine if the issue is present
  - Company specification was modified to require monitoring axial vibration during acceptance tests with acceptance criteria.

- Axial vibration should be checked/monitored in the field